Development of the real-time monthly to seasonal hydrologic forecasting system for the western U.S. focused primarily on increasing the number of streamflow forecasting points, increasing the level of automation of spinup and forecasting procedures, interactions with agency forecasting groups, expansion to a multi-model framework, and testing of new assimilation techniques. Our proposal was partitioned into five operations and three science tasks (see Appendix A for listing of tasks). Our work during Year 2 has been directed towards Operations Tasks 1, 2, and 4 and Science Task 5.

During winter 2004-2005, real time hydrologic forecasts for the western US domain were made once monthly, augmented by bi-monthly updates in the Colorado R. basin from January-April, and for the Pacific Northwest from March-May.

In consultation with NRCS National Water and Climate Center (NWCC) forecasters, 30 new forecast points were calibrated for the Colorado R. basin, and about 60 new points are in development for the Missouri River basin (forecast domain expansion – see Figure 1). Additional points are also in development in the Klamath and Yakima River basins, the Great Basin and upper Rio Grande R. basin (Figure 1). The upper Missouri R. basin is the first step toward expanding the domain eastward to the Mississippi R. basin. To assist with the process of calibrating streamflow simulations, we have also tried to implement an automatic calibration routine, but this work is as yet incomplete.

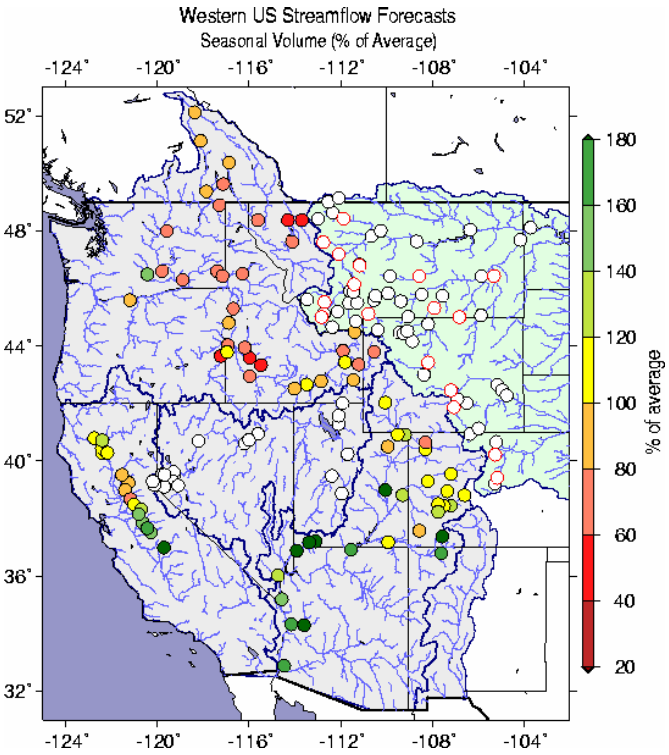

Figure 1 -- Streamflow forecasting locations, including 30 new points in the Colorado R. basin, and 60 points in development in the Missouri River basin.

Interactions with the NWCC also led to the development of basin average water balance analyses and displays that will soon appear on the forecast system website (which has been also been redesigned), and to regular exchanges of forecast results and analyses immediately prior to the NWCC forecast coordination with the CBRFC and NWRFC forecast offices. An effort was also made to install and run elements of the forecast system within the NWCC forecast office in Portland, OR, but institutional constraints and efficiency considerations argued for the arrangement that forecasts would be run at UW and shared with NWCC instead. In the end, one UW water supply forecasts (for the Virgin River, in February) were used directly as the coordinated official forecast, and were used for evaluation purposes by NWCC staff throughout the winter of 2004-2005 in the southwestern U.S.

Forecast results were also presented at over a dozen meetings and prepared for a Washington State emergency water group in connection with the regional drought. An example of this work is shown in Figure 2.

The methods for generating critical spin-up period model forcings were also revisited, and a completely automated version of this software was designed and tested in a 1/2 degree resolution implementation spanning the entire continental US (CONUS). Provisionally named the *UW Experimental Surface Water Monitor* (see Figure 3), it has become an operational hydrologic/drought monitoring system in its own right, and is consulted regularly by authors of the US Drought Outlook. For this effort, a set of climate index stations for the CONUS domain was developed and new automatic data streams were implemented using the NOAA Applied Climate Information System. A website was created for displaying daily (real-time) updates to the data products, as well as an archive of linked products extending back to 1915.

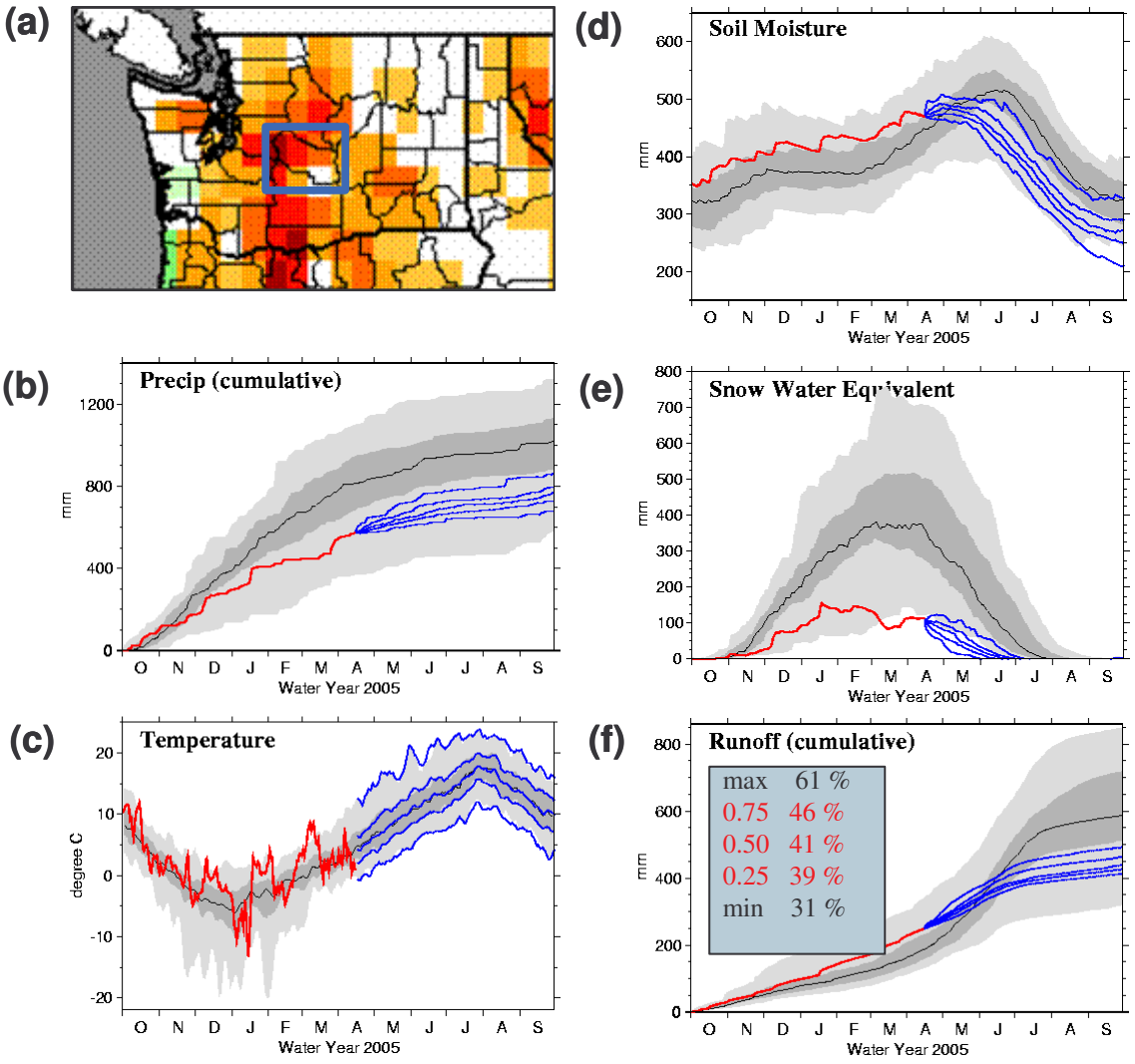

Figure 2 -- Nowcast and forecast ensemble time series of hydro-climatic variables for the Washington State county shown by blue box in (a) during Water Year 2005. The current condition (red) and mid-April forecast range (blue) is shown against the 1971-2000 distribution (gray), for (b) cumulative precipitation, (c) temperature, (d) soil moisture, (e) snow water equivalent, and (f) cumulative runoff, for which the calculated forecast anomalies at different percentiles are also shown (inset).

A pilot implementation of a multiple land-surface ensemble framework for producing the forecasts is also underway, focusing on the Salmon River basin in Idaho. For this multi-model system, a set of control scripts have been designed and tested; these are currently configured for the grid-based NWS Sacramento model and the NOAH model, but are extensible to other models as well. Methods for combination of model results are also being tested, including multiple linear regression and Bayesian Model Averaging.

A new ensemble Kalman Filter-based approach for assimilation of snow water equivalent (remotely sensed by microwave instruments and also ground observations from NRCS SNOTEL stations) was also evaluated over the Pacific Northwest domain. The results of this work are being published in Andreadis and Lettenmaier (2005).

Relevant Publications

Andreadis, K.M., and D.P. Lettenmaier, 2005, Assimilating Remotely Sensed Snow Observations into a Macroscale Hydrology Model, *Advances in Water Resources* (in press).

Wood, A.W. and D.P. Lettenmaier, 2005, A testbed for new seasonal hydrologic forecasting approaches in the western U.S., *Bull. Amer. Met. Soc.* (submitted).

Wood, A.W., A. Kumar and D.P. Lettenmaier, 2005, A retrospective assessment of climate model-based ensemble hydrologic forecasting in the western U.S., J. Geophys. Res. 110, D04105, doi:10.1029/2004JD004508.

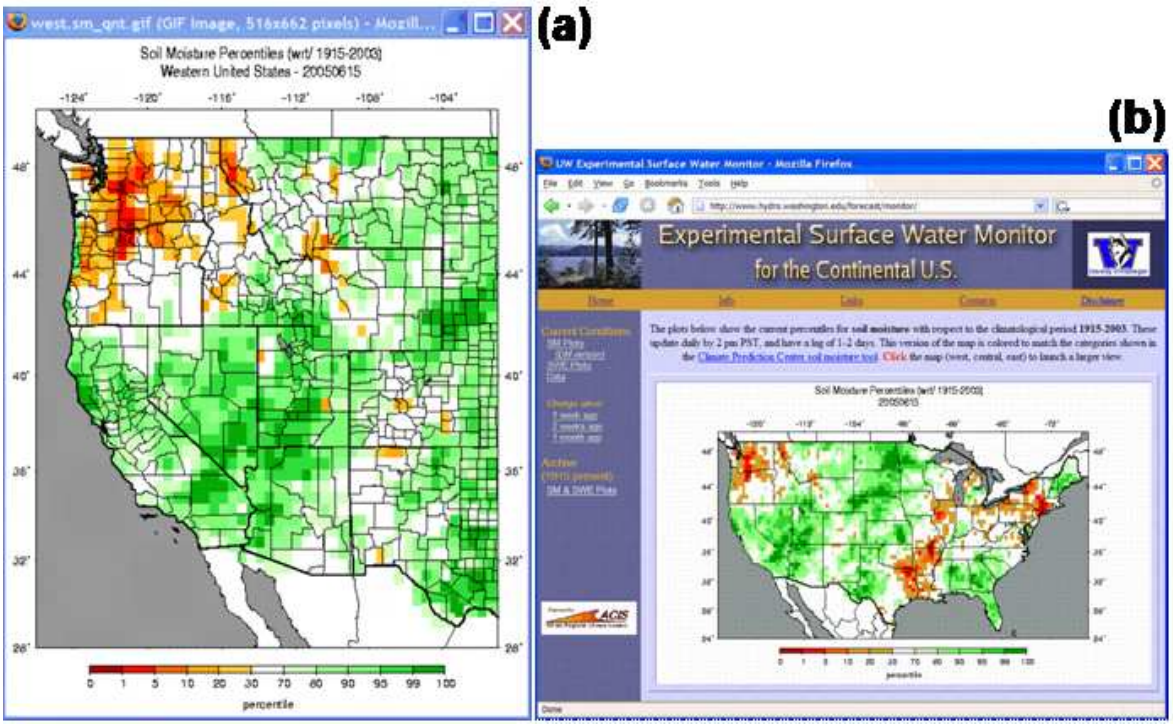

Figure 3 -- (a) an example of a SW Monitor county-level plot (in this case, of soil moisture percentiles) launched by clicking on the national scale maps shown on (b) the website. The color bar is matches that used in the CPC soil moisture tool plots, and another version reflecting the Drought Monitor categories is available. Other plots relate to snow water equivalent and runoff, and changes over a 1 and 2 weeks, and 1 month.